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Climate Change Impact on Groundwater in Cheliff-Zahrez basin (Algeria)

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Abstract

Groundwater is a very widely used resource in the Cheliff-Zahrez watershed. However, following the drought in the basin, farmers of the region has resorted to the intense mobilization of groundwater resources. This work allowed us to study the impact of rainfall reduction on groundwater resources in the basin, by studying groundwater and natural infiltration. We have considered the future scenarios to estimate rainfall for 2025 and 2050 and therefore the (groundwater) recharge at those time horizons.

Keywords: Climate change; Groundwater; Chellif-Zahrez; Algeria

1. Introduction

Our work aims to study the impact of climate change on the renewal of groundwater resources in the Cheliff-Zahrez watershed. This study is based on the analysis of relations between climate changes and natural recharge of groundwater. The general trends of climatic variations in the basin are first identified. The impact of this climate changes on aquifer recharge is also discussed in order to complete the identification of climate indicators that managers can use to adapt to changes in groundwater resources. The renewal of this resource depends on the recharge of groundwater which depends on rainfall and evapotranspiration [1].

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Several recent studies have shown that climate trends are well correlated with the variations of groundwater level [2] [3].

2. Material and method

2.1. Geographical and Climatic Framework

The region includes three drainage basins: the Cheliff basin in the north, the Zahrez-Sersou basin in the south and the coastal in the north (Fig.1). It is bounded on the north-west and west by the coastal basin of Oran and the Macta basin, and on the east, by the coastal basin of Algiers and the Hodna basin. It is characterized by a semi-arid to temperate climate. The examination of the rainfall map of the Cheliff-Zahrez watershed [4] highlighted two distinct areas: one in the north includes the Cheliff Valley and the Ouarsenis Massif where average rainfall is between 450 and 600 mm, except in the Zaccar Gharbi Massif where we records more than 700 mm. The other is located in the south and includes the plateau of Sersou and Zahrez where rainfall varies between 100 and 300 mm.

2.2. Geological and hydrological framework

The Cheliff-Zahrez watershed includes two distinct structural units:

– in the north, the Cheliff furrow flanked by the two Tellian chains (Dahra Mountains to the north and the Ouaresnis Massif to the south).

– in the south, the Zahrez basin.

The Cheliff furrow is compartmentalized into three basins (higher, middle and lower Cheliff) separated by two thresholds corresponding to the bedrock, the threshold of Ain defla and the threshold of Oum D'rou further west. Many permeable geological formations contain groundwater, the oldest are assigned to the Jurassic time and the most recent correspond to the quaternary alluvium. In the northern part of the study area, the two Tellian chains are poor resources and it is difficult to exploit them directly, the permeable levels (limestone and sandstone) are generally less developed and encased in powerful formations that have a very low permeability.

In the Cheliff basin, the alluvial plain consists of coarse alluvium and occupies an area of 376 km^2. Many drilling capture this coarse alluvium of 150 m. the depth of groundwater is between 20 and 60 m with operating flows in the order of 30 to 70 $L \cdot s^{-1}$. In the Zahrez basin, extends a watertable bounded on the north by the Ain Oussera Plain, on the west by the plateau of sersou, on the east by the Chott Hodna and on the south by the Ouled Nail Mountains. The aquifer consists of sands with intercalations of quaternary clays and scree slopes of dunes and alluvium, which reaches a thickness of 200 m in the filling of the two Zaire in the south.

2.3. Groundwater

The groundwater of the « Cheliff-Zahrez region » was assessed within the framework of the National Water Plan. This assessment is based on quantitative hydrogeological studies carried out by the National Agency of Water Resources and the method of rain/infiltration for the non-studied areas.

The number of hydrogeological units in the Cheliff-Zahrez region is 42 units, whose groundwater potential is estimated at 298 Hm^3.

2.4. Situation for the Period 1961-1990

The estimation of groundwater potential is established for the same period using the approach based on average rainfall, geological formations (their surfaces and permeabilities) represented by an infiltration coefficient. Thus, for an average amount of water of 346.5 mm rushed at the level of Cheliff basin, that is to say a water volume of 16 381.9 Hm^3, the groundwater potential is estimated at 299 Hm^3/year, spread over the various aquifers of the Cheliff basin.

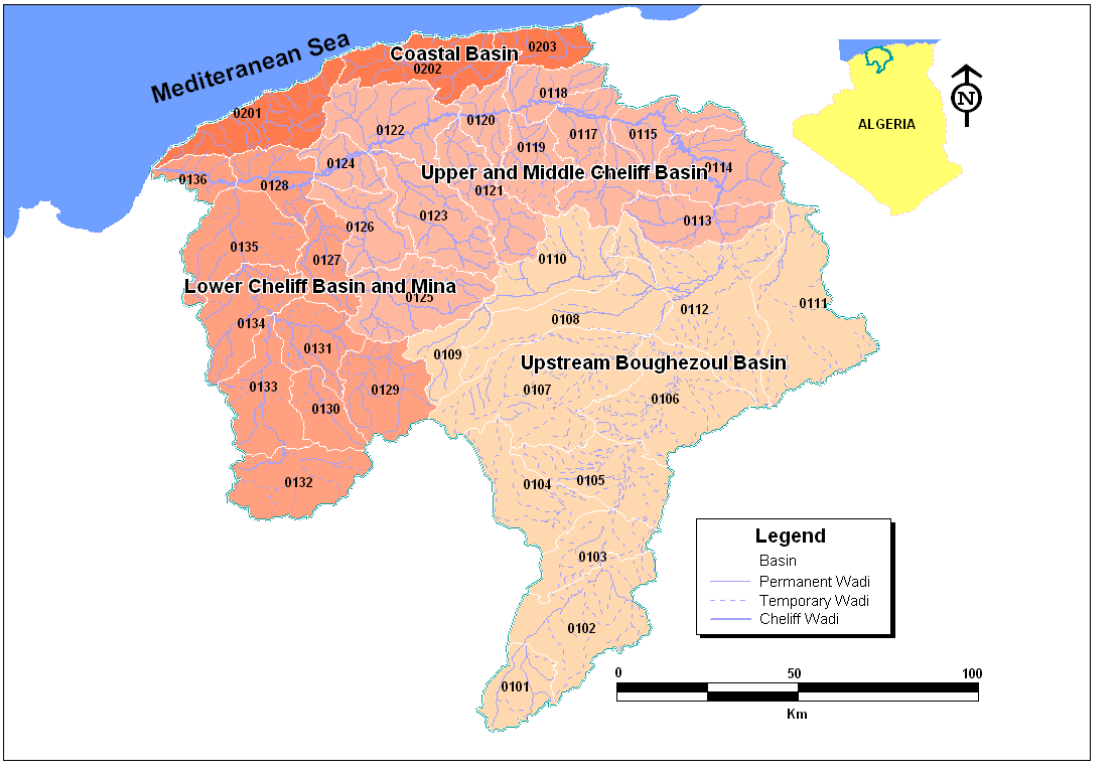

Fig. 1. Studied basins

2.5. Data and Rainfall Variability

The available data collected from the National Agency of Water Resources are of two types: climatological and piezometric. The evolution of the available data in the 221 rainfall stations distributed throughout the Cheliff Zahrez watershed and the boundary sub-basins, depending on the longest operation period, clearly shows the low density of rainfall network before 1966. It has become very important in the late sixties and early seventies, where more than 60% of rainfall stations have the information during the period 1968/1969 to 2001/2002. Thus, the longest observation series are situated between 1968 and 2001. This period was therefore chosen as the reference period. The rainfall regime has changed from the seventies in the Cheliff-Zahrez region. Thus, we are seeing the emergence of a rainfall deficit from 1970, which continues throughout the decade 80-90 [6]. The pluviometric index shows a great spatiotemporal variability from one decade to

another (1950/50 a surplus of 14,5 %), the decade 1980-1990 was characterized by a pluviometric deficit on the whole of the studied zone and this phenomenon persisted during the 1990s [7] [8] [9] [4]. Algeria, like the Maghreb [10] and Mediterranean countries [11] [12], suffered from several periods of drought: the first water shortage was felt from 1943 to 1948 and had a significant impact on crops and livestock; the second one is the one we are suffering from since 1975.

Table 1. Rainfall characteristics (1968–2000)

Name of the station	X (km)	Y (km)	Altitude (m)	Mean (mm)	Standard deviation (mm) and CV in %
Marabout Blanc	460	316	335	309	67.2 (21.8)
Ghrib Bage	487	318,	460	452	113 (25)
El Khemis	459	328	285	425	110.7 (26.1)
El Esnam	620	336	430	355	119.8 (33.7)
Relizane	305	275	81	273	67.8 24.9)

In fact, rainfall decreases as one moves away from the east coast to the west coast. The rainiest region is that in the north eastern basin characterized by high altitudes and its exposure to the northern wind. The average annual rainfall varies between 600 to 700 mm. Rainfall doesn't exceed 500 mm in the plain, while in the south of the Cheliff-Zahrez region, the high plateaus and the Zahrez the annual averages range from 100 to 300 mm. Overall, the wettest months are: November, December, January and February. However, the months of July and August are almost completely dry. A filter of 3-years moving averages was applied in order to highlight the main trends. The periods 1980-1994 and 1998-2001 are characterized by a significant rainfall deficit recorded on the different stations.

3. Evolution of groundwater potential for 2020 and 2050

To study the impact of climate change on water resources, we have used the seasonal climate projections on Algeria for 2020 and 2050 obtained by the UKHI model (United Kingdom Meteorological Office High Resolution) by adopting the « IS92a » scenario of GIEC with both high and low assumptions.

Table 2. Reduction of groundwater potential by horizon

Sub- region	Groundwater potential for (Hm3/year)			
	2020		2050	
	Low	High	Low	High
Cheliff upstream Boughzoul	142,3	138,9	134,6	126,8
Higher and middle Cheliff	82,6	80,9	77,9	73,9
Lower Cheliff and the Mina	57,2	55,9	53,9	50,9
Coast	3,6	3,5	3,4	3,2
Total	285,7	279,3	269,9	254,9
Reduction (%)	4,4%	6,6%	9,7%	14,8%

3.1. Impact of climate change on groundwater

We have estimated the groundwater potential for 2020 and 2050 (Table 2) using the approach rain/infiltration and taking into account the different climate scenarios. The potential decreases for 2020 from 4.4% (low scenario) to 6.6%

(high scenario). For 2050 (high scenario), the groundwater potential of the Cheliff region would be 255 Hm^3 that is to say a reduction of 15% compared to the reference period 1961-1990. For the low scenario, the potential would be reduced by about 10% for 2050.

4. Conclusion

The reduction of rainfall over the past four decades has resulted in a decrease of the water volumes stored in dams. This situation has led to overexploitation of groundwater particularly for agriculture. In general, the evolution of groundwater potential was closely linked to rainfall fluctuations; these have also affected the management of these resources which had a negative impact on the groundwater level.

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